WITCH: Status and Perspectives

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Overview

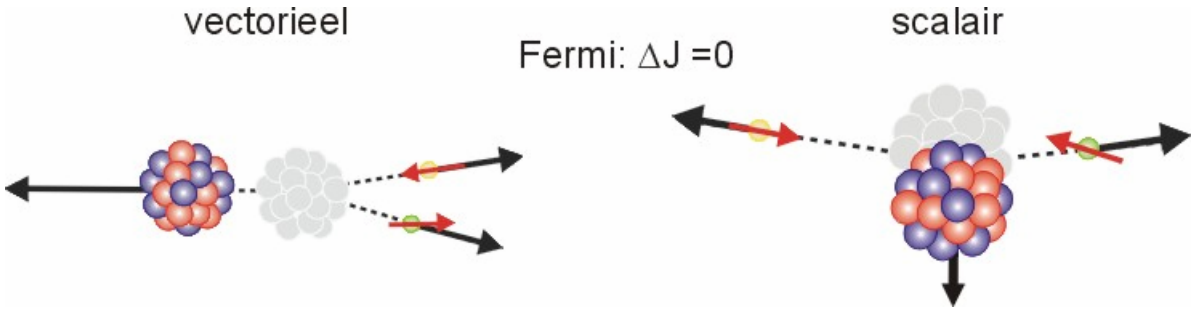
- Weak interaction and motivation WITCH
- Experimental Setup
- Nov 2006 ^{124}In-run
- Oct 2007 ^{35}Ar-run
- Improvements
- Conclusion and Outlook

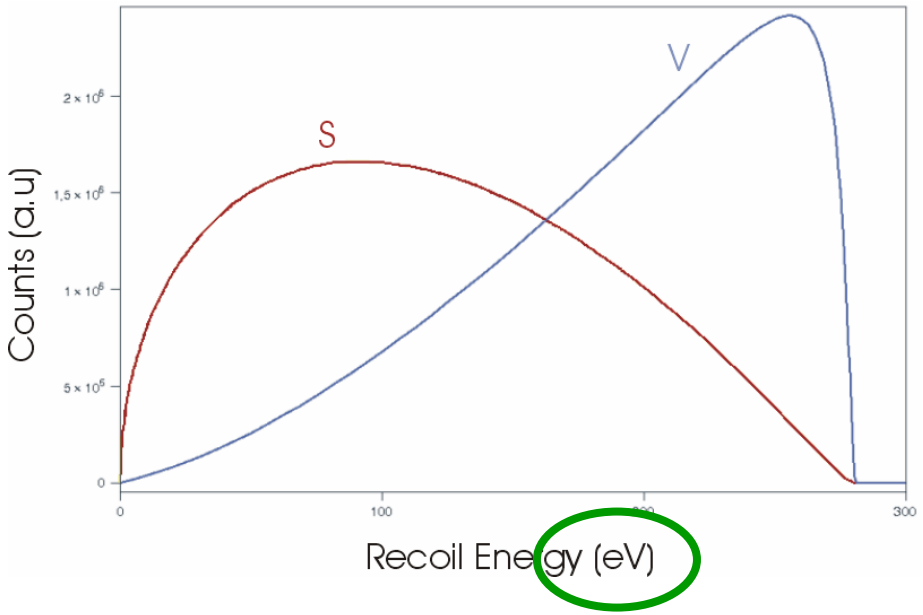
Weak
Interaction
Trap for
CHarged Particles

Motivation

$$\mathcal{H} = g \sum_{j=S,V,A,T,P} (\overline{\psi}_p \mathcal{O}^j \psi_n)(\overline{\psi}_\beta \mathcal{O}_j (C_j + C'_j \gamma_5)\psi_\nu) + h.c.$$

EXP: $|C_S/C_V| < 0.07$
$|C_T/C_A| < 0.09$

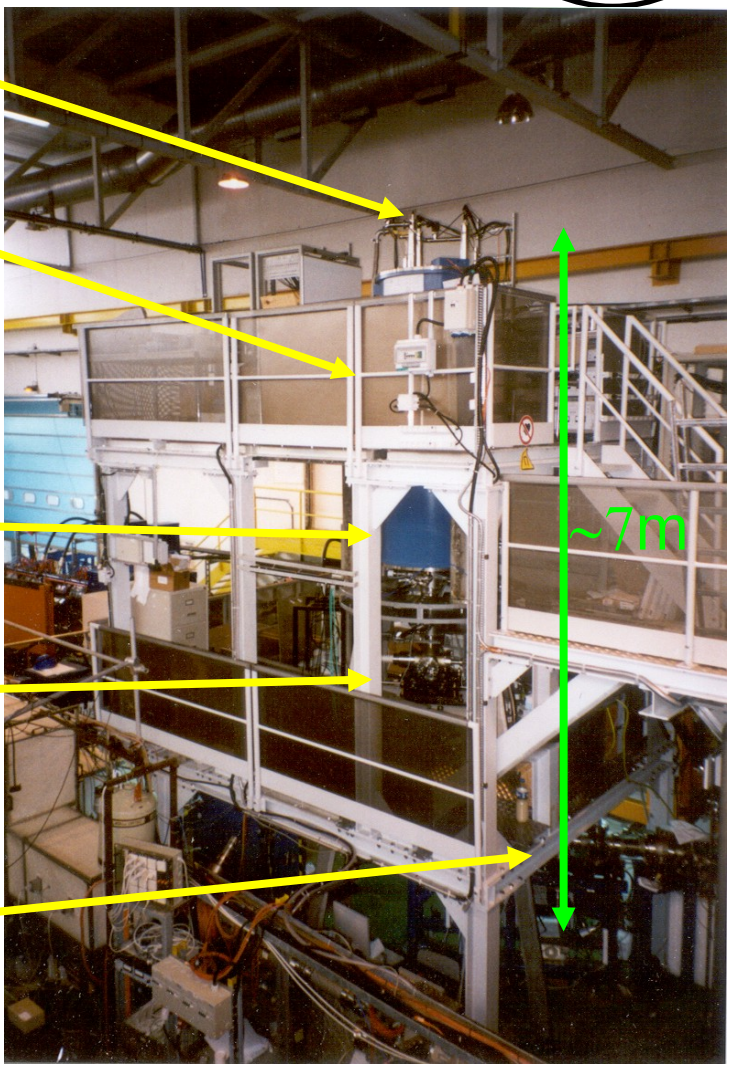




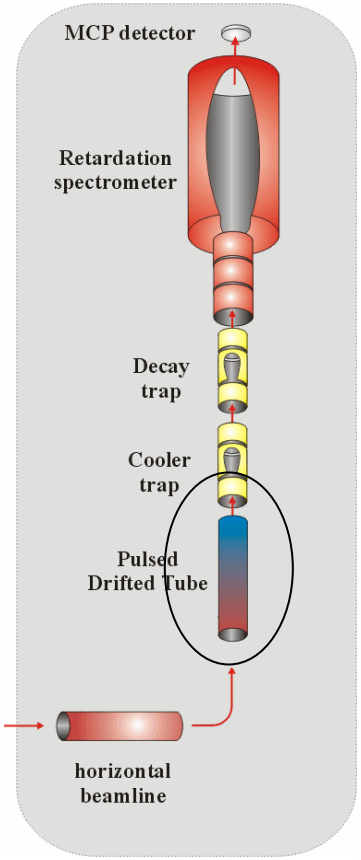
=>Search for scalar (or Tensor) Interactions
=>measure recoil spectrum

Low energy!
⇒Need for scattering free source

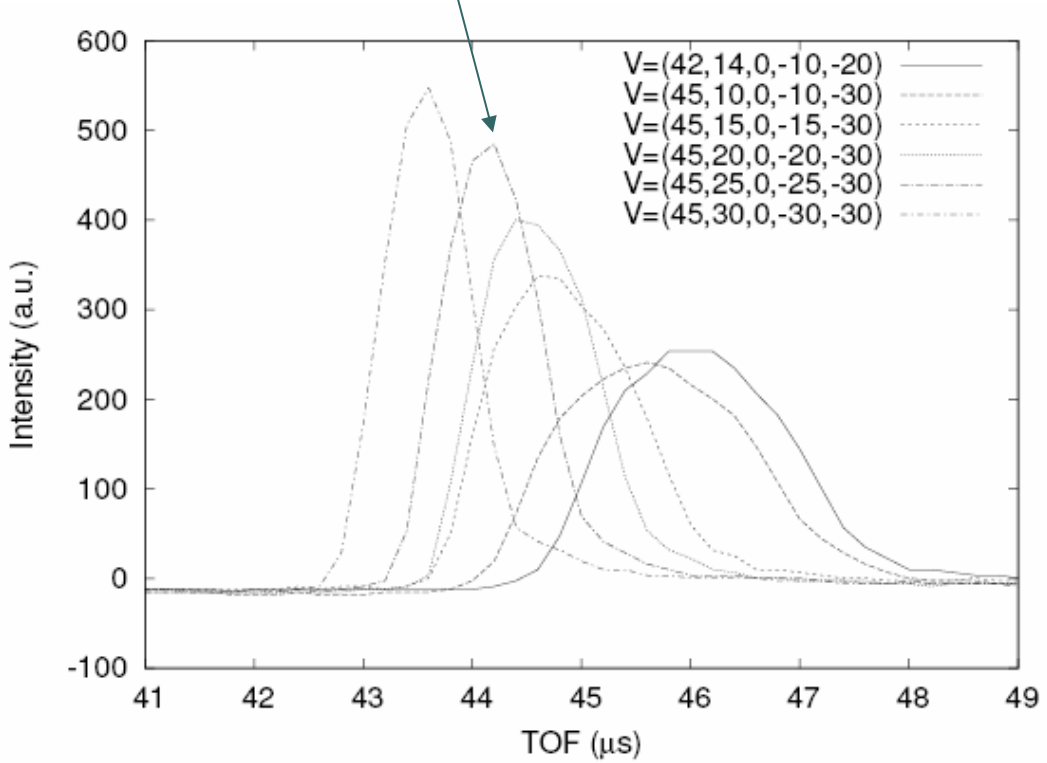
Experimental Setup

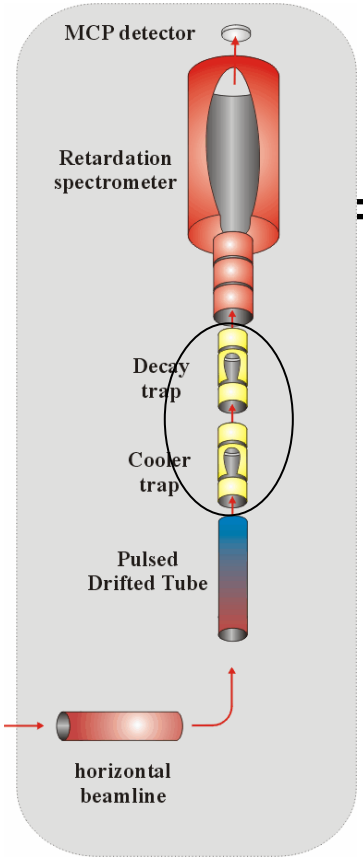


Pulsed Drift Electrode

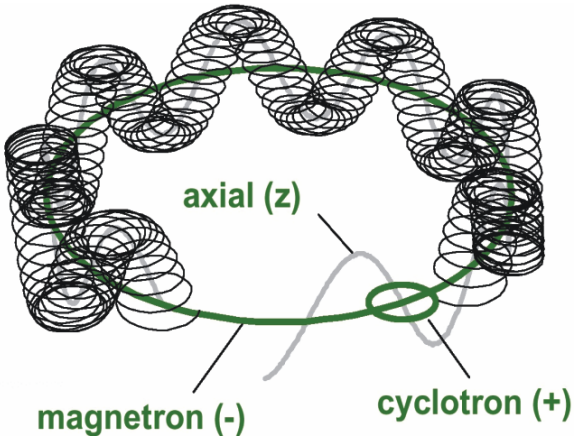


Improved PDT efficiency by shortening beam pulse delivered by REXTRAP



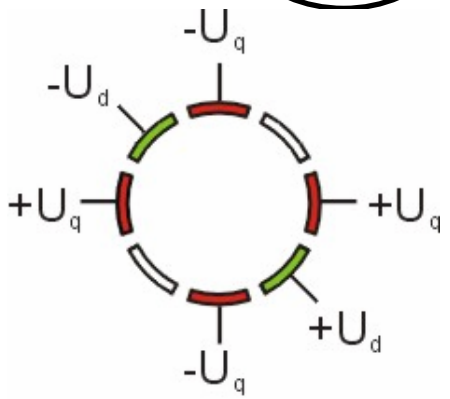


Penning Trap



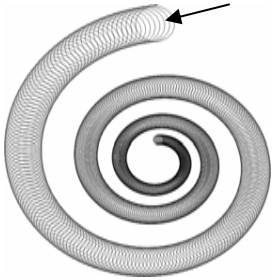
$$\omega_+ \approx \omega_c = \frac{qB}{m}$$

$$\omega_- = \frac{U_0}{2Bd^2}$$



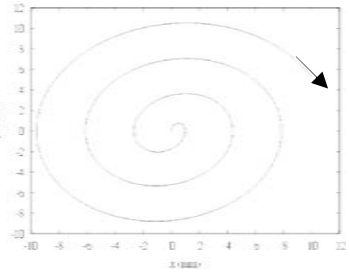
Quadrupole Excitation

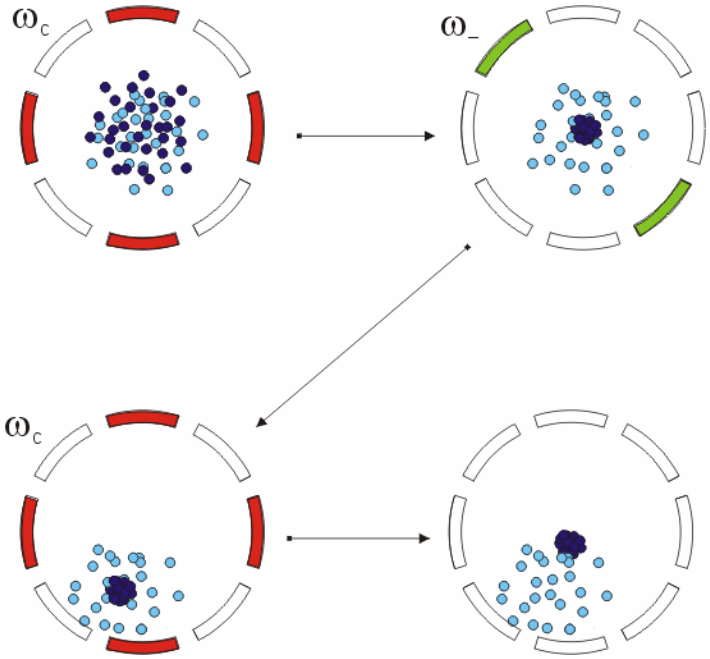
U_q, ω_c



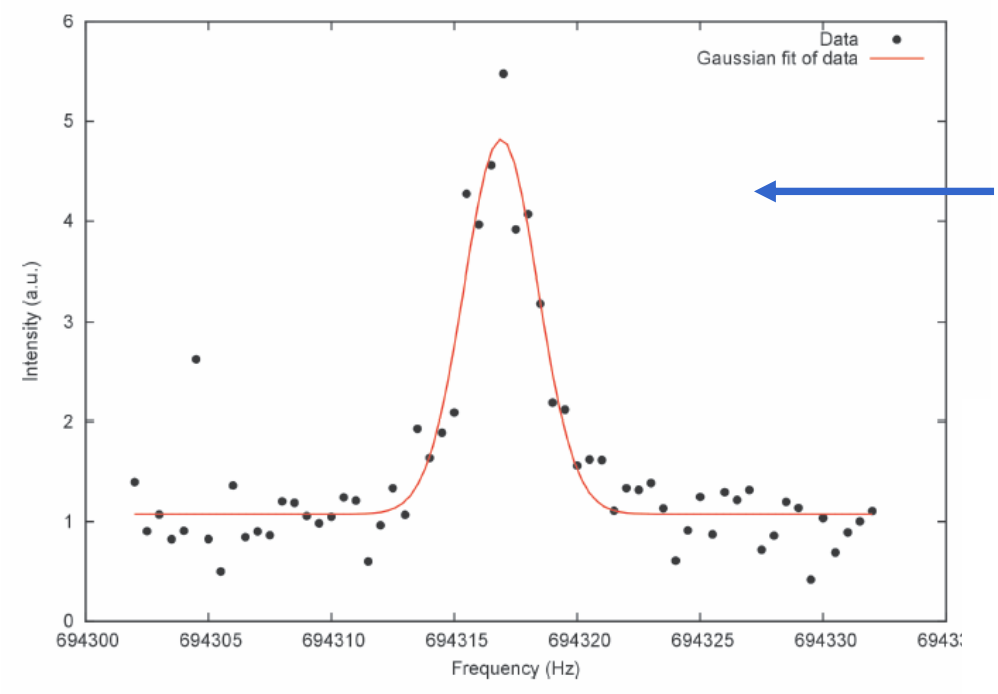
Dipole Excitation

U_d, ω_-



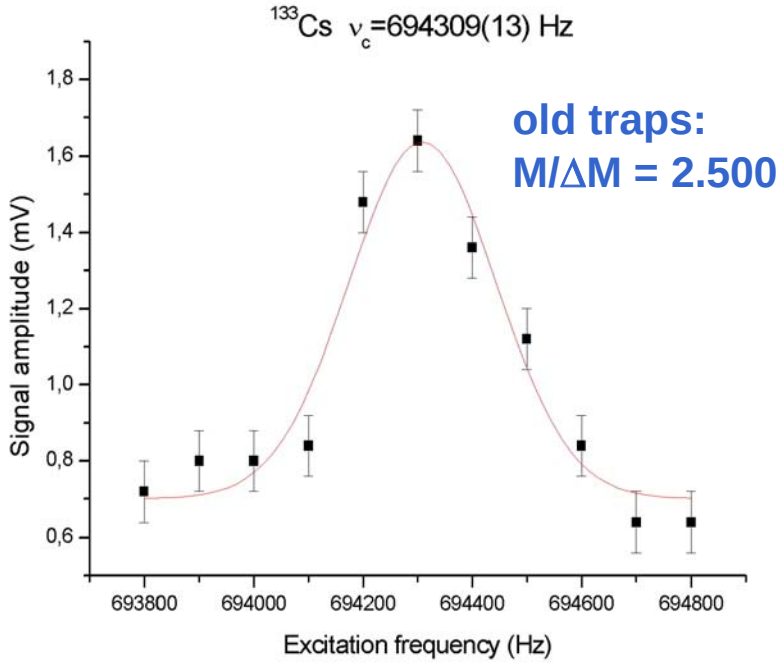


Improved mass res.



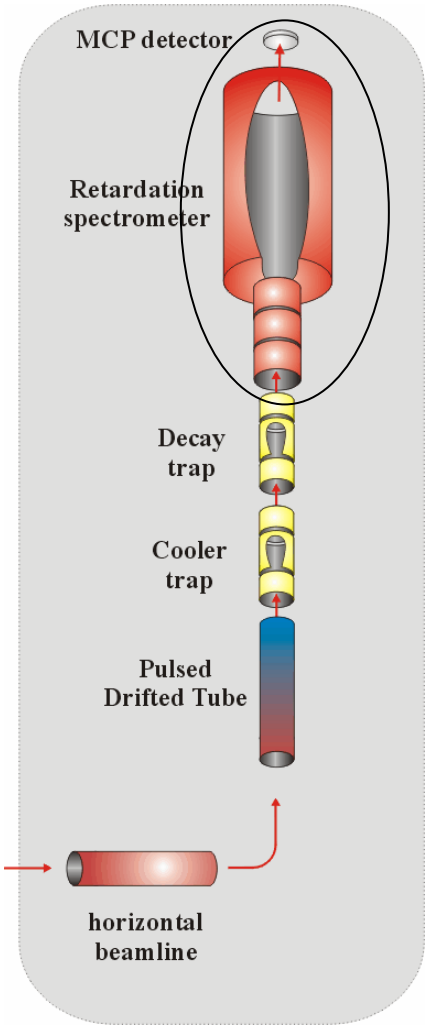
New and better coated traps
M/ΔM =200.000

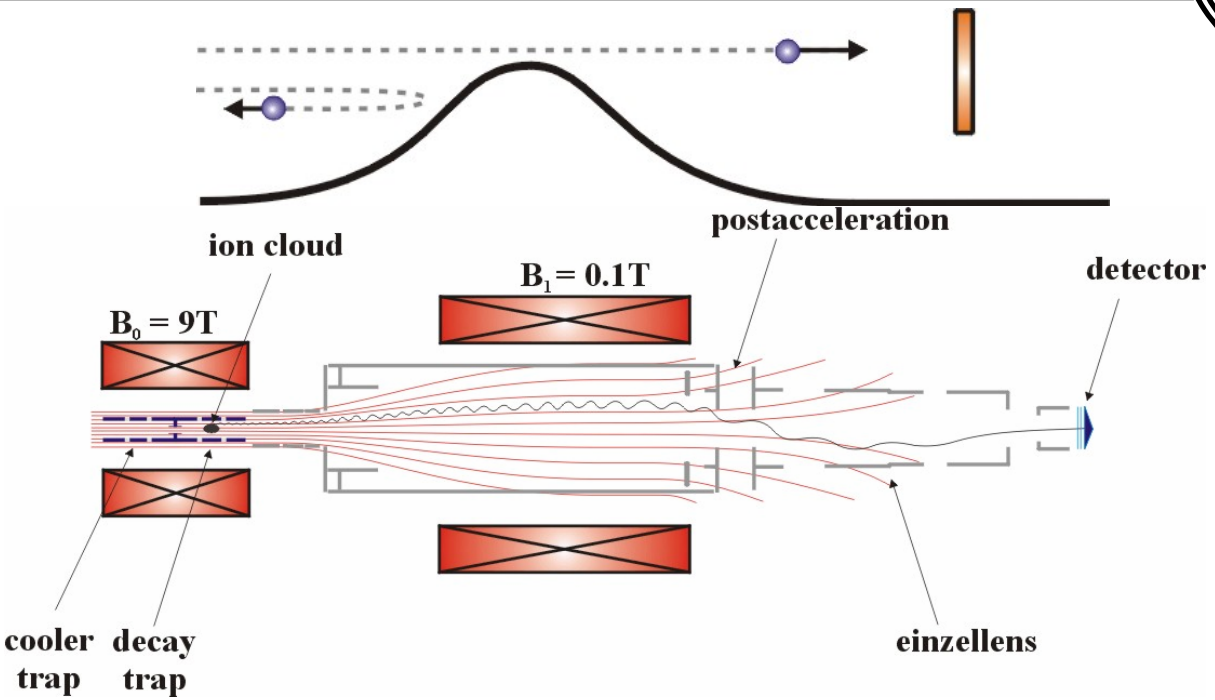
^{133}Cs cooling resonances

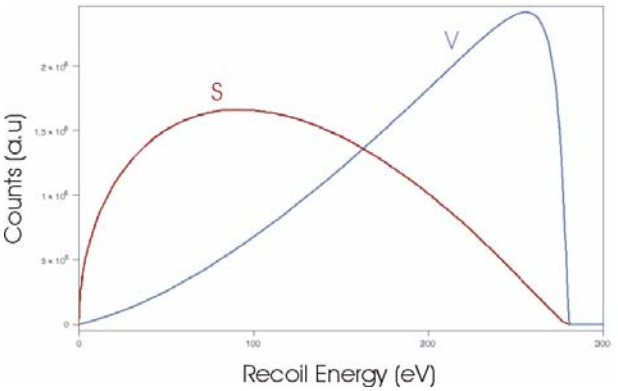


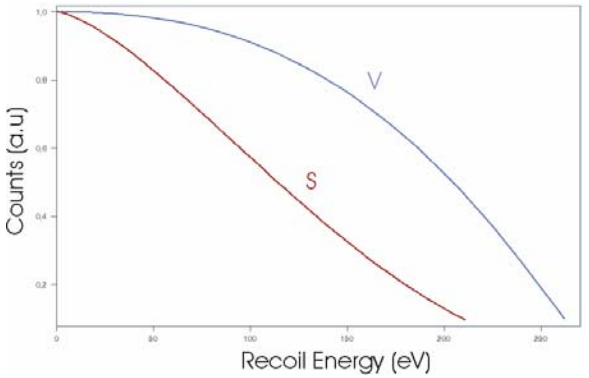
old traps:
M/ΔM = 2.500

Retardation Spectrometer

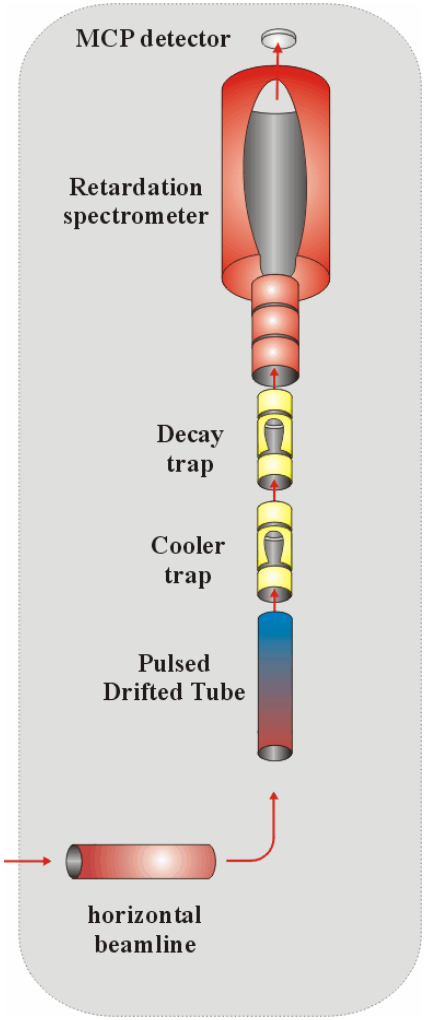








Efficiency Overview



	ideal	2004	2007
HBL	100%	100%	100%
PDT	100%	~8%	50-100%
injection in magnetic field	100%	~1%	~20%
Cooler trap	100%	45%	45%
tranfer between traps	100%	80%	80%
Decay trap	100%	100%	100%
fraction of ions from trap to spectr.	40%	45%	45%
fraction with lowest charge after decay	10%(*)	10%(*)	10%(*)
transmission trough spectrometer	100%	100%	~100%
MCP efficiency	60%	50%	52%
Total efficiency	~1%	~0,001%	~0,1%

(*) ~80% if β^- decay

Choice of isotope

1 Production yield at ISOLDE > 10^6-10^7 particles per second
2 Halflife: order of 1 s
3 Low ionization potential (charge-exchange)
4 Preferably β⁻decay (shake-off)
5 Daughter isotope stable
6 Minimal isobaric contamination
7 Simple decay scheme

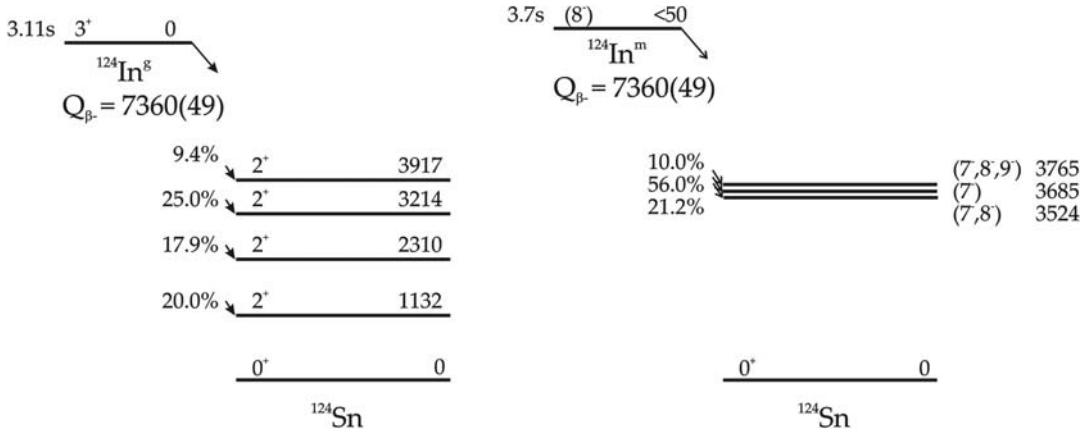
^{35}Ar: not 3 and 4

Beam wanted: ^{122g}In → β⁻decay $T_{½}$ = 1.5 s

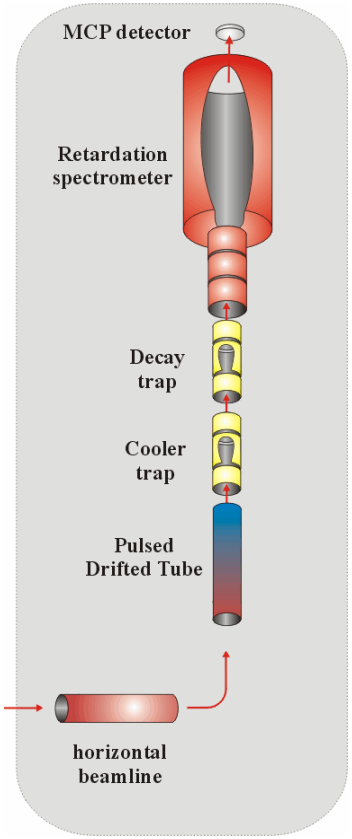
NOT PRODUCED, all $^{122}In^{m1,2}$

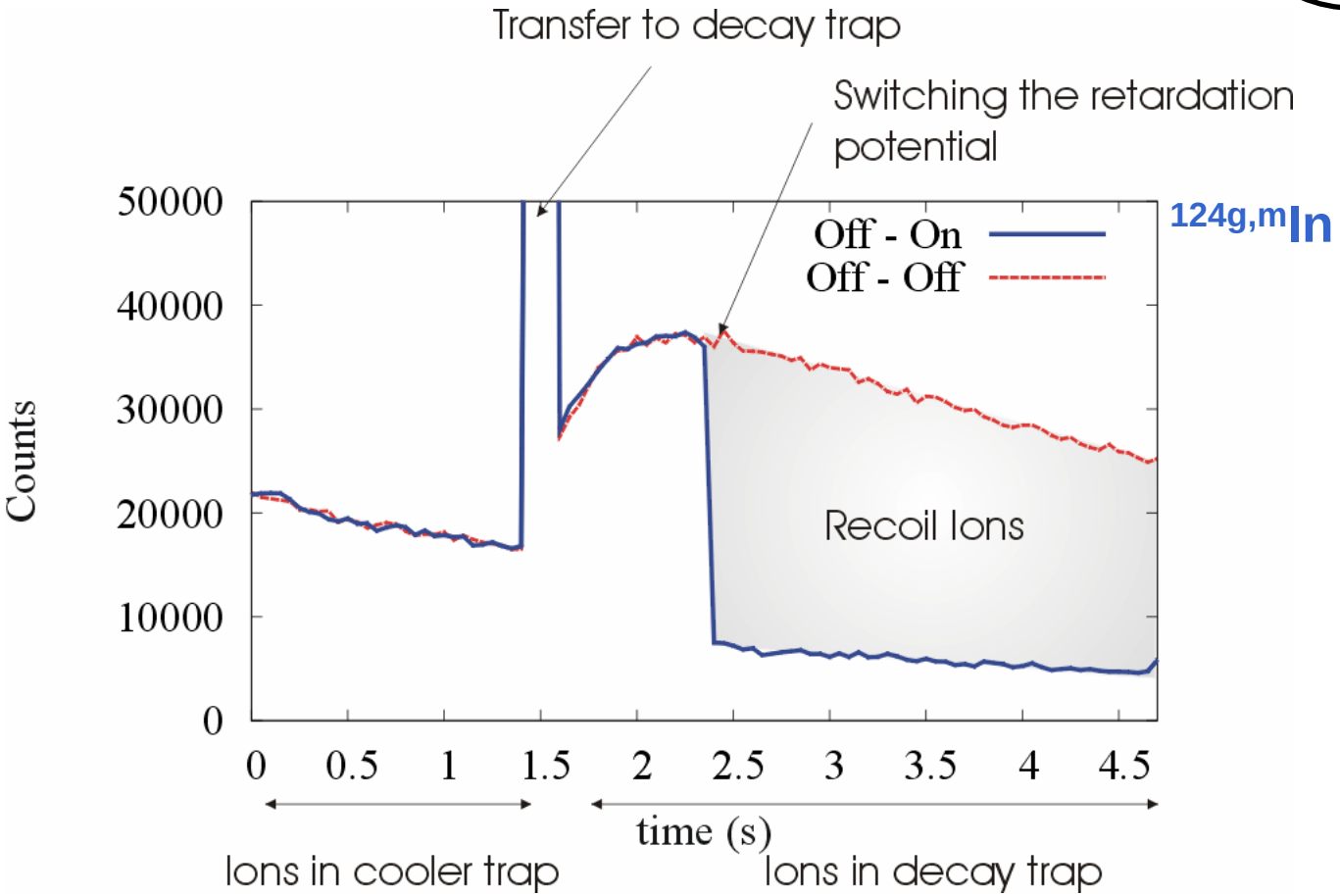
Beam used: ^{124g}In + ^{124m}In
decay scheme is more complex

$T_{½}(^{124g}In)$ = 3.11(10) s
$T_{½}(^{124m}In)$ = 3.7(2) s



Results nov 2006

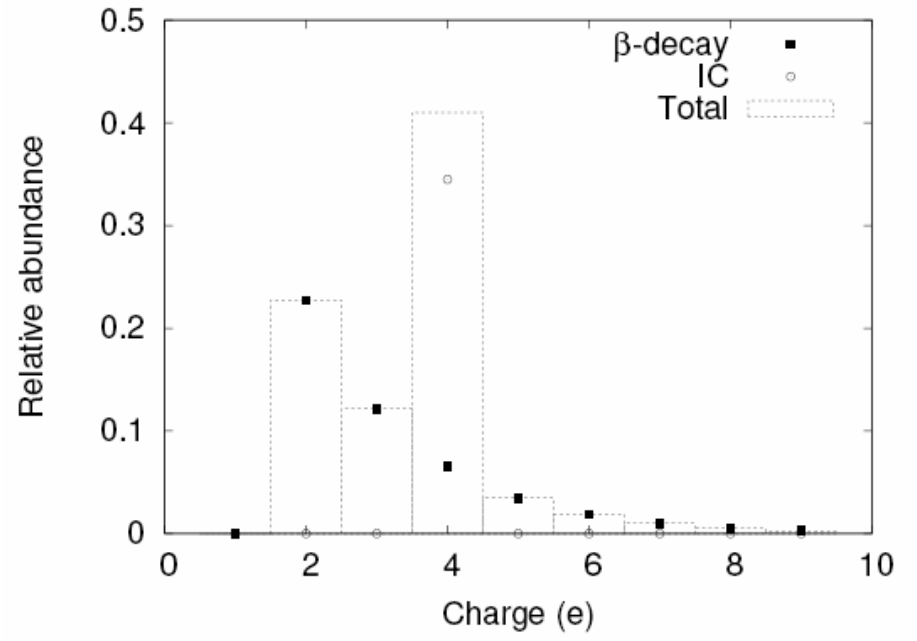




First observation of recoil ions with WITCH

Results nov 2006

charge state distribution of ^{124}Sn recoil ions



→pure β shake-off

sudden change of el potential for the orbital electrons

→Auger processes

β⁻decay off In-ion: 2+ state

Auger cascade of loosely bound 5s electrons ($4d^{10}\ 5s^2$)

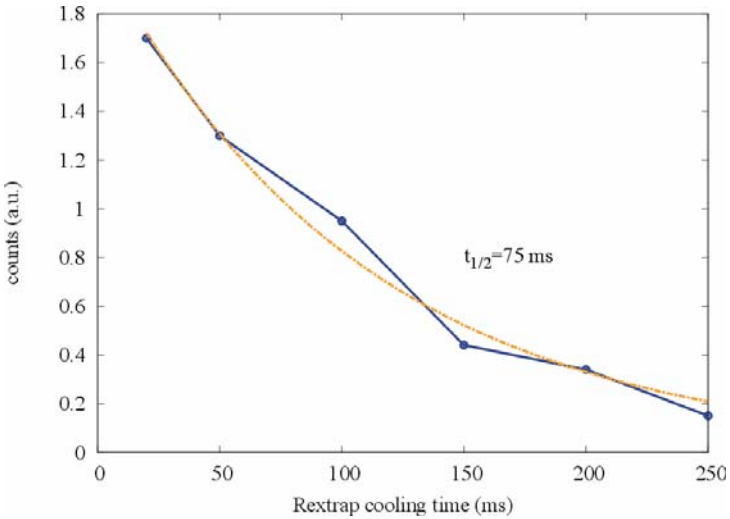
=>4+ state

Auger cascade is created by the removal of an inner orbital electron.

First run on ^{35}Ar

failed due to:

- **>> contamination with stable ^{35}Cl (Cl in the cleaning agent to clean the ion-source)**
- **> losses of ^{35}Ar due to charge exchange in REXTRAP (improvements planned)**
- **> losses of ^{35}Ar due to charge exchange in WITCH (vacuum upgrade ongoing)**
- **'secondary ions', ('Penning traps' in spectrometer ?)**



Improvements

ISOLDE (Ar-test 5-9 may)

- use "Cl-free" target material and target cleaning procedure
- remove remaining ^{35}Cl with selective mass cooling in REXTRAP
- increase Ar lifetime in REXTRAP

WITCH Short time

- improve WITCH vacuum to $\leq 1 \times 10^{-9}$ mbar (NEG coated electrodes)
- improve buffer gas system
- study origin of 'secondary ions' and solve problem
- pulsed buffer gas injection in PenningTraps (further cooling after transfer)

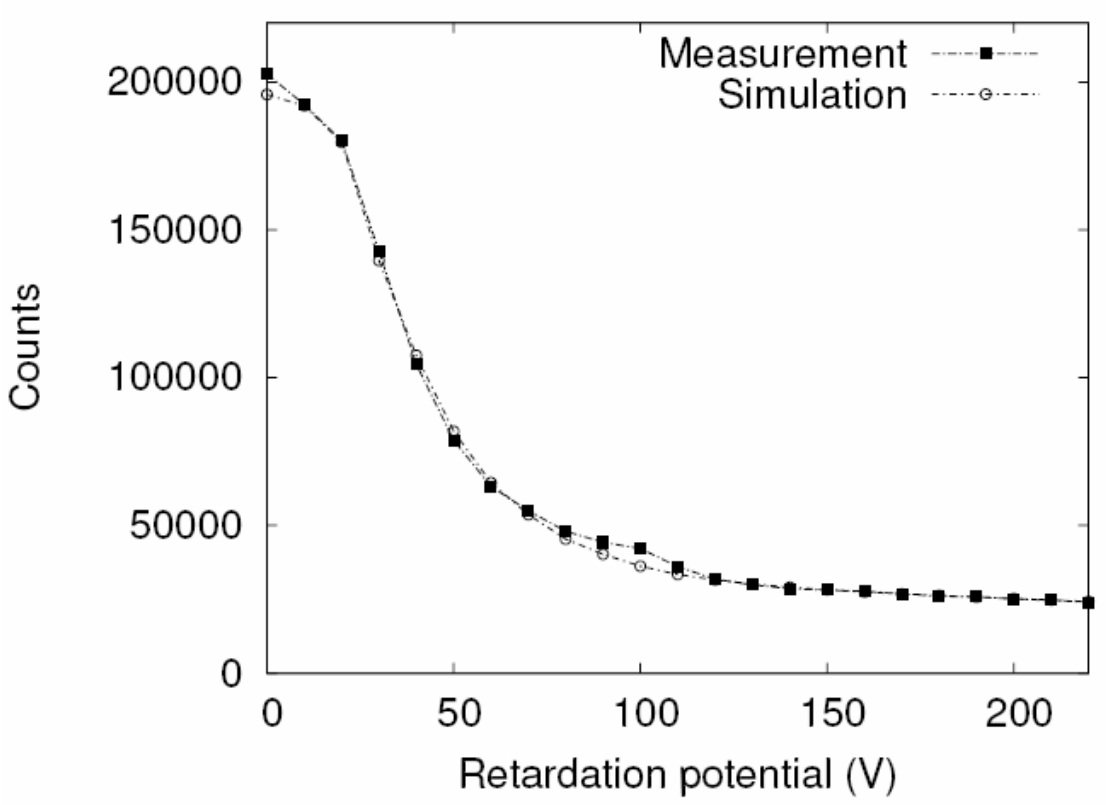
WITCH longer time

- new support structure for Penning traps (e.g. to add detectors)
- install magnetic shielding (→ independent from REX-ISOLDE, they use much beamtime)
- improve intensity of WITCH 60 kV RFQ ion source (→ independent from REXTRAP)
- building TAPESTATION for in-trap for mass separation

Conclusion and Outlook

- Improved efficiency off the total setup.
- First recoil spectrum measured.
- First measured charge state distribution for a non noble-gas.
- Proof of principle is given.
- Lots of problems (Vacuum, secondary ionisation!,…)
  -> next run, hopefully at the end of this year.

Results nov 2006



integral energy spectrum for ^{124}Sn recoil ions

Element	Configuration	Auger maximum (EC or IC)
Ar	$2p^6 3s^2 3p^6$	3 [22]
Kr	$3d^{10} 4s^2 4p^6$	5 [21]
Xe	$4d^{10} 5s^2 5p^6$	8 [20]
In^{1+}	$4d^{10} 5s^2$	4 [this work]

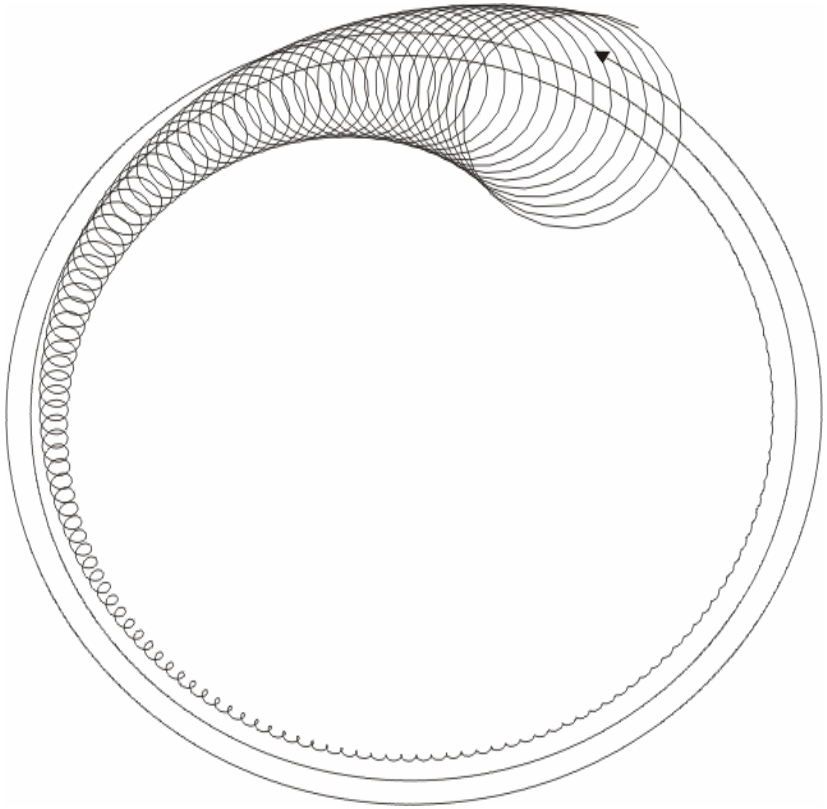
[20] A.H. Snell and F. Pleasonton, Phys. Rev. **111** (1958) 1338.

[21] D.J. Decman and W. Stoeffl, Phys. Rev. Lett. **64** (1990) 2767.

[22] M.M. Hindi, *et al.*, Phys. Rev. C **58** (1998) 2512.

[buffergas]

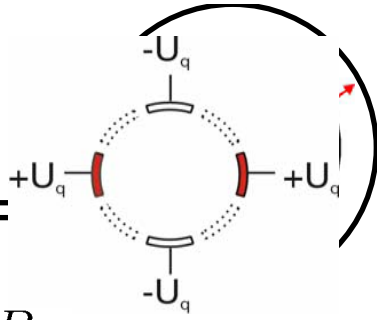
In eerste benadering dempingskracht $\mathbf{F}_D = -\delta m\dot{\mathbf{r}}$



$$\delta \propto p/T$$

cyclotronstraal daalt ~ 20 ms
magnetronstraal stijgt ~ 200 s

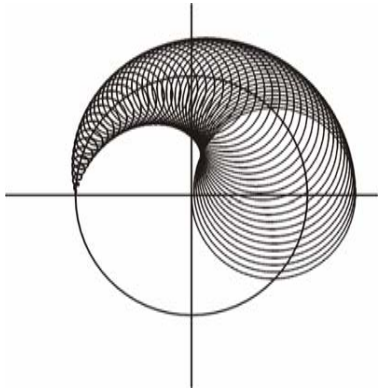
[quadrupool]

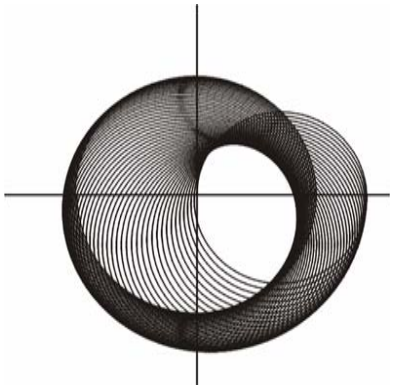


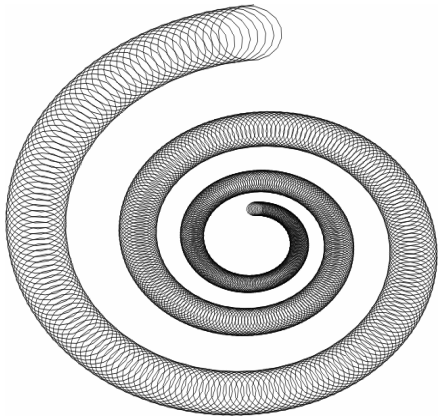
$$\omega_c = \frac{qB}{m}$$

$$\Phi_q = \frac{U_q}{{\rho_0}^2} \cos(\omega_q t - \phi_q).(x^2 - y^2)$$

Continue omzetting van magnetronbeweging in cyclotronbeweging. En vice-versa.

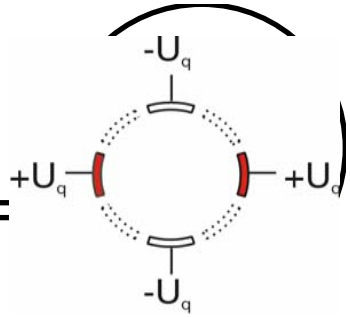


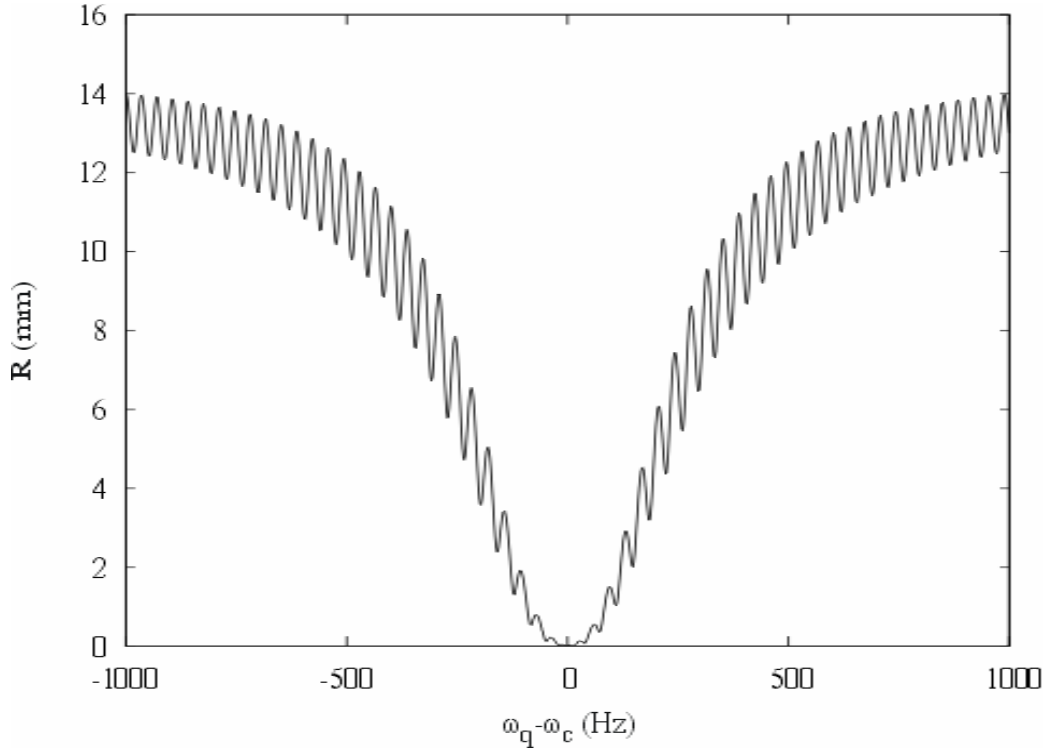




Quadrupoolexcitatie ω_c + buffergas -> cyclotronbeweging verliest energie door buffergasbotsingen
-> de afstand van ion tot centrum daalt.

[massresolution]





Frequentiescan geeft informatie over massaresolutie via: $\omega_c = \frac{qB}{m}$

$$\frac{\Delta\nu}{\nu} = \frac{\Delta m}{m}$$

vb: ^{35}Ar scheiden van ^{35}Cl

[Witch v2.0]

- Bad vacuum: ionization in system
- Charge exchange in traps with Noble gasses
- Secondary ionization (no solution yet)

[Witch v2.0]

- Getter strips
- Remove all teflon (peek?)
- Electro polishing of electrodes

- Pulsed buffergas (also good considering known Temp for fitting puls high distribution)